

## Anterior Segment Anatomy

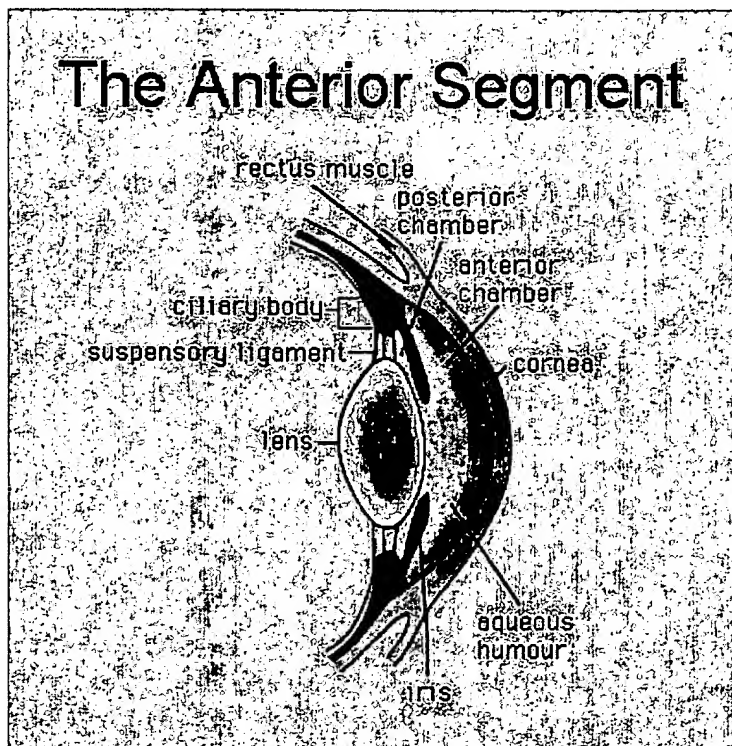


Figure 3. Anterior segment (adapted from Encyclopedia Britannica)

Anterior segment surgeons (such as myself), define this part of the eye as extending from the anterior hyaloid face forward. Externally the demarcation is marked by the limbus. However, since many of us were trained as generalists, we occasionally will make a foray into the posterior segment much to the consternation of the vitreo-retinal surgeons (who have nothing to say since they will sometimes sneakily extract a cataract by way of the *pars plana*).

## Cornea

The cornea, the clear dome-shaped window at the front of the eye, provides 85% of the light bending (focusing) power of the eye. It is made up of tissue similar to that of the sclera with two exceptions:

- it is clear
- it has no blood vessels

It is made up of 5 distinct layers. Starting from the outer layer and moving inward, they are:

**The epithelium:** the multi-layered outer part — has numerous fine fingers called *microvillæ*, on the outermost cellular layer which serve to hold the tears in place longer (it's rather more involved than that but live with it). The bottom layer of these cells attach themselves to **Bowman's Layer** (sometimes and erroneously termed a membrane) by structures called — *hemidesmosomes*. These

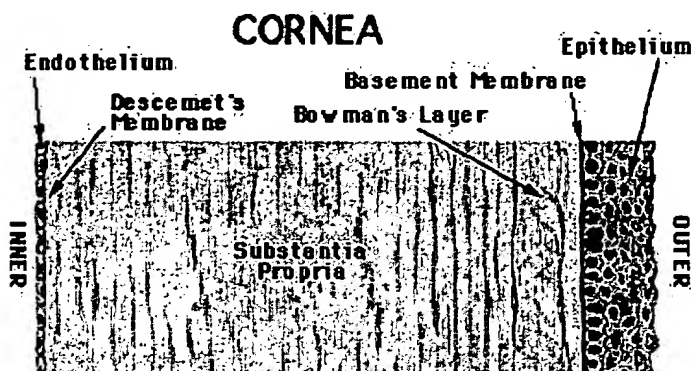


Figure 4. The corneal layers

hemidesmosomes are destroyed by the **Bowman's Blasting**. The bare corneal nerve fibers end within the epithelial cell layer which explains why corneal abrasions hurt so damned much!

Bowman's layer is a condensation of the outermost portion of the corneal stroma (*substantia propria*). On histological sections it appears amorphous and separate from the underlying keratocytes.

**Corneal stroma:** (*substantia propria*) is made up of elongated bands of Type I and V collagen arranged in a lamellar array. These lamellæ have an average thickness of 2 µm and extend across the breadth of the cornea. The collagen fibers which make up the lamellæ are embedded in a hydrophilic matrix made up primarily of a substance called glucosaminoglycan (GAG). This stuff soaks up water like a sponge and a good thing too. Since there are no blood vessels within the clear cornea this matrix along with the endothelial cells serves as a rudimentary circulatory system. Water containing nutrients comes in from the limbal edges and is actively pumped out by the endothelial cells. The hydrostatic pressure within the normal cornea is approximately 50 mm Hg.

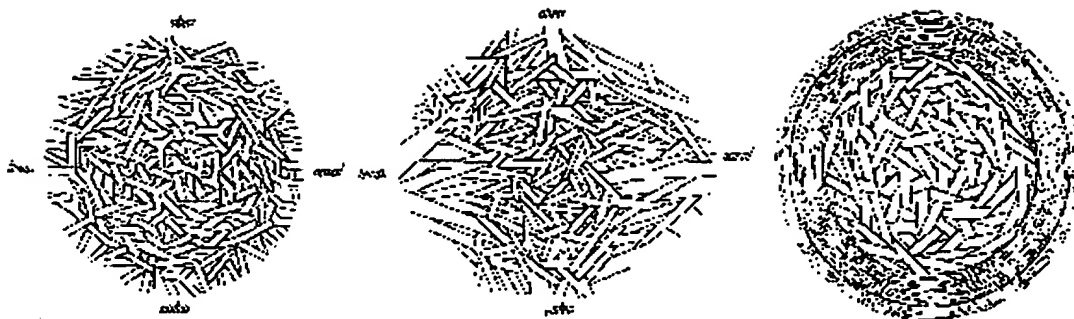


Figure 5. Kokott, W., Über mechanisch-funktionelle Strukturen des Auges. Gräfes Arch Ophthalmol, 138: p. 424-485; 1938.

The corneal lamellæ are arranged in layers and tend to orient themselves more or less randomly in the superficial layers and to the major recti muscles internally with the exception of the inner peripheral-most layer where they are arranged circumferentially. Kokott was the first to describe this layering pattern which was recently confirmed by more modern means. It is this uneven arrangement of the fibers which makes constructing an adequate finite element model (FEM) of the cornea so difficult (see Biomechanics of the cornea).

**Descemet's membrane:** is a highly elastic membrane which serves much the same purpose as does Bowman's layer in that the inner most layer of the cornea — the endothelium.

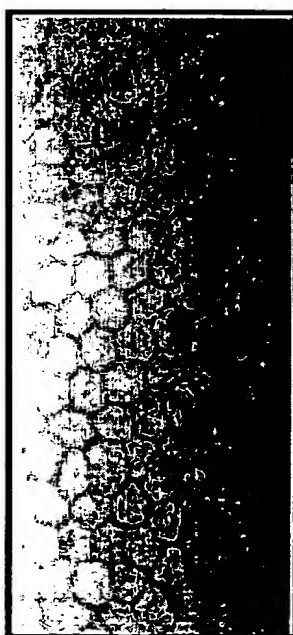


Figure 6. endothelium

**The endothelium:** is the inner, single cell layer of the cornea. These cells form a tightly packed and waterproof mosaic forming the inner lining of the cornea.

These cells are busy fellows, serving in much the same way as did the windmills in Holland. They actively pump water out of the cornea keeping it transparent. The eye only gets one set as well; that is, these fellows do not regenerate once lost — which is what all the brouhaha is over endothelial cell loss during **cataract surgery**. Normally the eye will lose about 10% per decade of life. When a cell is lost, the others enlarge to fill up the gap as much as they can. If they cannot completely fill the gap, then those · ood old · GAG's soak up the aqueous causing the stromal fibers to move apart. Once the separation of these fibers exceeds  $\frac{1}{2}$  the wavelength of light, light begins to become scattered and vision suffers. Too much fluid in the cornea and the cornea becomes opaque.

Once that happens the epithelium may become blistered (*bullous keratopathy*) and blood vessels may start to migrate into the once clear cornea. When that happens, a penetrating keratoplasty (corneal transplant) may become necessary.

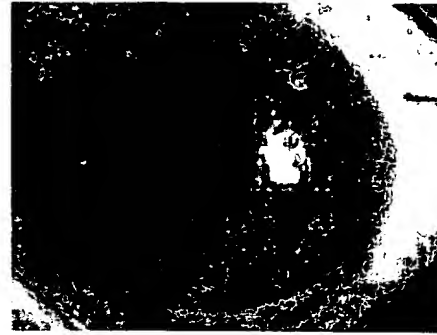


Figure 7. cloudy cornea

## Anterior Chamber

Just beneath the cornea is a fluid-filled space called the *anterior chamber*. This fluid — the aqueous — is produced by the *ciliary body* (located in the posterior chamber) and bathes the whole of the anterior segment providing nourishment to and removal of breakdown products to the lens and cornea. The aqueous flows out from behind the iris, percolates within the anterior chamber and then leaves through a sieve-like ring at the junction of the iris and the cornea — the *angle*. Normally this fluid is water-clear but in cases of inflammation of anterior segment structures such as the iris, inflammatory cells and proteinaceous fluids escape into the aqueous. The presence of the cells produces a Tyndall effect called *flare* when properly illuminated by a slit-lamp biomicroscope and the cells can be seen moving in a circular movement downward when near the cooler cornea and upward when near the warmer lens.

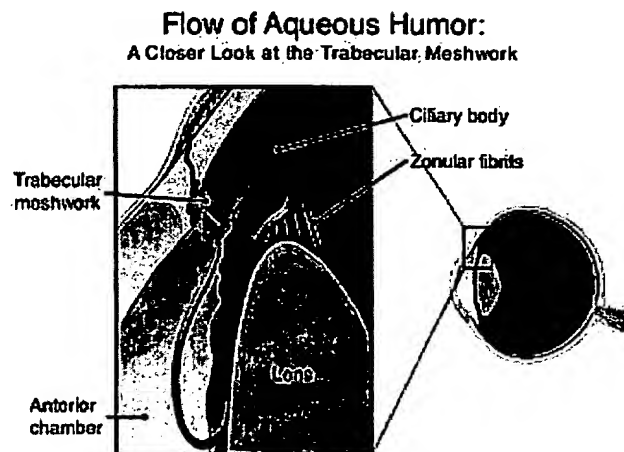


Figure 8. aqueous flow

The **ciliary body** is extremely important to the health and function of the eye being as it is the source of the nutrient fluid called *aqueous* and also houses the muscular fibers which cause the eye to focus. The lens of the eye, made up of the capsule, cortex, and nucleus, is held under tension by the zonular membrane and thus is made thin. In this idling configuration, in the normal eye, the eye is able to discern distant objects clearly. As an object gets closer, the eye must change its light bending power to accommodate the nearness of the object. This is accomplished by the contracture of the ciliary muscles which are so arranged that when they

contract, the zonule relaxes allowing the lens to also relax and thus get thicker in the center. This increased thickness bends the light more so that nearer objects are seen more clearly. It should come as no surprise that the act of focusing is called *accommodation*.

**Iris:** Overlying the lens, is a structure made of thin elastic tissue with an opening in the center which is surrounded by a circular muscle called a *sphincter*. This structure is called the *iris* and the opening — the *pupil*. It is the iris that determines the color of the eye — blue, brown, etc. The backside of this tissue is made up of cells containing brown pigment which acts to absorb light as well as prevent its scattering within the eye. The front layer of tissue varies in thickness; the thicker it is, the bluer the eyes appear to be when seen through the clear cornea. The purpose of the iris is to control the amount of light entering the eye and thereby prevent dazzle by bright lights. As the pupil gets smaller in bright light, the acuity of vision typically increases through a process called *defraction* and by the fact that less of the peripheral cornea is involved limiting the amount of *spherical aberration*. Camera buffs should get the idea immediately.

The place where the iris meets the cornea is called the *angle*. The iris blends into the sclera via a mesh-like fibrillar structure called the *trabecular meshwork* (see **Glaucoma**). This area is normally wide open to about 30° or so. If this angle gets narrower — the angle is said to be compromised. In such a condition — the intraocular pressure (IOP) might go up causing *narrow-angle* or '*creeping-angle-closure*' glaucoma. Some circumstances could cause this area to narrow to 0° — an ocular emergency — *angle closure glaucoma*.

**Lens:** Behind the iris lies the *lens*. It is the lens that provides near vision in our youth and which gets gradually stiffer as we age and less focusable. It is the lens that gradually becomes more and more cloudy — a condition called **cataract** — with age. The potential space behind the iris, which includes the lens and zonule up to the hyaloid face, is called the *posterior chamber*.



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